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Structural Analysis of Lunar Subsurface with Chang'E 3 Lunar Penetrating Radar

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Geological structure of the subsurface of the Moon provides valuable information for our understanding of lunar evolution. Recently, Chang'E 3 has utilized lunar penetrating radar (LPR), which is equipped on the lunar rover named as Yutu, to detect the lunar geological structure in Northern Imbrium (44.1260N, 19.5014W) for the first time. As an in-situ detector, Chang'E 3 LPR has higher horizontal and vertical resolution and less clutter impact compared to spaceborne radars such as Chandrayaan-1 and Kaguya.

In this work, we analyze the LPR data at 500 MHz transmission frequency to obtain the shallow subsurface structure of the landing area of Chang'E 3 in Mare Imbrium. First, filter method and amplitude recover algorithms are introduced for data processing to alleviate the adverse effects of environment and system noises and compensate the amplitude losses during signal propagation. Next, based on the processed LPR data, we present the methods to determine the interfaces between layers. A three-layered structure of the shallow surface of the Moon has been observed. The corresponding real part of relative dielectric constant is inverted with deconvolution method. The average dielectric constants of the surface, second and third layer is 2.8, 3.2 and 3.6, respectively. The phenomenon that the average dielectric constant increases with the depth is consistent with prior art. With the obtained dielectric constants, the thickness of each layer can be calculated.

One possible geological picture of the observed three-layered structure is presented as follows. The top layer is lunar regolith with its thickness ranging from 0.59 m to 0.9 m. The second layer is the ejecta blanket of the nearby impact crater, and the corresponding thickness is between 3.6m to 3.9m, which is in good agreement with the model of ejecta blanket thickness (height) as a function of distance from the crater center proposed by Melosh in 1989. The third layer is regarded as early lunar regolith with 4-6m thickness. The echoes below the third layer are in the same magnitude as the noises, which may indicate that the fourth layer is uniform (no echoes) and its thickness is beyond the detection limit of LPR.